

# ASEN/CSCI 5264: Decision Making under Uncertainty

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## Prerequisites

- Basic familiarity with probability
- Basic familiarity with linear algebra and multivariable calculus (e.g. matrix inversion, gradients)
- Fluency in a high level programming language and willingness to learn Julia.

## Rough Schedule and List of Topics

(See Ed for detailed and updated schedule.)

### 1. Probabilistic Models:

- Probability
- Conditional probability
- Markov processes
- Introduction to Bayesian networks

### 2. Markov Decision Processes:

- Markov decision processes (MDPs)
- Value iteration (contraction proof of convergence)
- Policy iteration
- Approximate dynamic programming
- Online tree search

### 3. Reinforcement Learning:

- Exploration and exploitation
- Bandits
- Model-free RL
- Model-based RL
- Deep Q learning
- Policy gradient
- Actor-critic
- Entropy Regularization

### 4. POMDPs:

- Hidden Markov models
- Bayesian filters
- Particle filters
- Partially observable Markov decision processes (POMDPs)
- Exact POMDP methods
- Offline POMDP methods
- Online POMDP methods
- QMDP

### 5. Other Topics:

- Games and multi-agent interaction
- Meta and transfer learning
- State of the art overview (e.g. Recent Deep RL Algorithms)

## Websites

- **Ed** will host course discussions, announcements, and host solutions that are not posted publicly. Students are encouraged to ask questions here. Rather than emailing questions to the teaching staff, I encourage you to post your questions on Ed. The class signup link is at <https://edstem.org/us/join/4amqms>.
- **Gradescope** will be used for all assignments and exams.
- **Github** will be used to host all course materials at <https://github.com/CU-ADCL/CU-DMU-Materials>.

## Attendance and Participation

Learning is a collaborative effort between the instructor and students. If students are registered for the in-person section, they are expected to attend class and participate in discussions and exercises. Remote students are expected to watch the recorded lectures, ask questions on the Ed discussion board if there is confusion, and monitor course announcements delivered via Piazza or email.

## Textbook

Mykel J. Kochenderfer, Tim A. Wheeler, and Kyle H. Wray, *Algorithms for Decision Making*. 2022. Available Online: <http://algorithmsbook.com>. \$95.00.

## Additional References

- Richard S. Sutton and Andrew G. Barto, *Reinforcement Learning: An Introduction*, 2nd Ed. MIT Press, 2018. \$80.00, Available online: <http://incompleteideas.net/book/the-book-2nd.html>
- Dimitri P. Bertsekas, *Dynamic Programming and Optimal Control*, Athena Scientific, 2012 (4th Ed.). \$134.50
- Mykel J. Kochenderfer, *Decision Making Under Uncertainty: Theory and Application*, MIT Press, 2015. \$70.00, Available online: <https://ieeexplore.ieee.org/book/7288640>
- Stuart Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach*, 4th Ed. Pearson, 2022.
- Tom Kwong, *Hands-On Design Patterns and Best Practices with Julia*, Packt Publishing, 2020. \$39.99
- Stefano Albrecht, Filippos Christianos, and Lukas Schafer, *Multi-Agent Reinforcement Learning: Foundations and Modern Approaches*. Available online: <https://www.marl-book.com/>
- Laura Graesser, Wah Loon Keng, *Foundations of Deep Reinforcement Learning: Theory and Practice in Python*. Pearson Education, 2020. \$50.00.

## Assignments and Grading

- **40% Homework Assignments.** There will be 6 large homework assignments, due approximately every two weeks. A typical assignment will consist of
  - Several conceptual questions or exercises.
  - One open-ended programming problem. Your solution will be evaluated locally with obfuscated code and the score submitted to a leaderboard. The best performers will share their solution in class.
- **30% Exams.** There will be three Exams consisting of several questions or exercises. Exams will be taken remotely and timed for approximately 90 minutes. You will have a 24hr period within which to take the exam. The instructor may decide to change the format for one of the exams depending on how the semester progresses.
- **30% Final Project.** A final project chosen by the student that ideally connects to their research. Deliverable will be a 4-8 page report. Project may be completed in teams of up to 3.

As of the beginning of the course, participation is not expected to be a factor in assigning grades, however it may become a factor at the instructor's discretion. The class will be notified if participation from that point forward will be considered.

## Late Policy

To ensure proper progression through the course, students are expected to begin assignments early and submit homework assignments on time. However, in order to provide for minor unforeseen events or responsibilities, students may turn in late homework assignments within 72 hours of the due date with a 10% penalty without any questions asked.

Exams must be turned in on time. If there is a technical error that causes you to miss the deadline, email me with images of the exam **immediately** so that I have a record of when you finished the exam. Penalties for missing an exam or final project deadline will be determined on a case-by-case basis.

If a student has a special circumstance such as a major medical procedure, major family responsibility, or a religious observance that will prevent them from completing course work on time, this should be coordinated with the instructor before the due date.

## Course Staff

**Instructor:** Professor Zachary Sunberg  
AERO 263 zachary.sunberg@colorado.edu  
**Office Hours:** Posted on Ed

**Teaching Assistant:** Collin Hudson  
collin.hudson@colorado.edu  
**Office Hours:** Posted on Ed

**Teaching Assistant:** Jiho Lee  
jiho.lee@colorado.edu  
**Office Hours:** Posted on Ed

## Meetings

T/TH 4-5:15 pm, AERO 111 – Lecture video will automatically be posted online after class - see Ed for link.

## Additional Policies

### Honor Code

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the Honor Code may include but are not limited to: plagiarism (including use of paper writing services or technology [such as essay bots]), cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. Understanding the course's syllabus is a vital part in adhering to the Honor Code.

All incidents of academic misconduct will be reported to Student Conduct & Conflict Resolution: StudentConduct@colorado.edu. Students found responsible for violating the Honor Code will be assigned resolution outcomes from the Student Conduct & Conflict Resolution as well as be subject to academic sanctions from the faculty member. Visit Honor Code for more information on the academic integrity policy.

### Accommodation for Disabilities, Temporary Medical Conditions, and Medical Isolation:

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. **Students should expect to receive accommodations for a timed assessment (e.g., exam) only if their faculty instructor(s) receive the student's accommodations letter at least 5 business days before the assessment, as a departmental policy, in order to facilitate administering the assessment.** Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website. Contact Disability Services at 303-492-8671 or DSinfo@colorado.edu for further assistance. If you have a temporary medical condition, see Temporary Medical Conditions on the Disability Services website.

If you have a temporary medical condition or required medical isolation for which you require accommodation, please notify the instructor as soon as possible so that appropriate accommodations can be made.

If you are sick or require isolation please notify the instructor of your absence from in-person activities and continue in a completely remote mode, as you are able, until you are allowed or able to return to campus.

Please note that for health privacy reasons you are not required to disclose to the instructor the nature of your illness or condition, however you are welcome to share information you feel necessary to protect the health and safety of others within the course.

## **Accommodation for Religious Obligations:**

Campus policy requires faculty to provide reasonable accommodations for students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. Please communicate the need for a religious accommodation in a timely manner. In this class, you must let the instructor know of any such conflicts within the first two weeks of the semester so that they can work with you to make reasonable arrangements. See the campus policy regarding religious observances for full details.

## **Preferred Student Names and Pronouns:**

CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

## **Classroom Behavior:**

Students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote, or online. Failure to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, marital status, political affiliation, or political philosophy.

For more information, see the classroom behavior policy, the Student Code of Conduct, and the Office of Institutional Equity and Compliance.

## **Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation:**

CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. University policy prohibits protected-class discrimination and harassment, sexual misconduct (harassment, exploitation, and assault), intimate partner abuse (dating or domestic violence), stalking, and related retaliation by or against members of our community on- and off-campus. The Office of Institutional Equity and Compliance (OIEC) addresses these concerns, and individuals who have been subjected to misconduct can contact OIEC at 303-492-2127 or email [CUreport@colorado.edu](mailto:CUreport@colorado.edu). Information about university policies, reporting options, and including confidential services can be found on the OIEC website.

Please know that faculty and graduate instructors are required to inform OIEC when they are made aware of incidents related to these concerns regardless of when or where something occurred. This is to ensure that individuals impacted receive outreach from OIEC about their options and support resources. To learn more about reporting and support for a variety of concerns, visit the Don't Ignore It page.

## **Mental Health and Wellness:**

The University of Colorado Boulder is committed to the well-being of all students. If you are struggling with personal stressors, mental health or substance use concerns that are impacting academic or daily life, please contact Counseling and Psychiatric Services (CAPS) located in C4C or call (303) 492-2277, 24/7.

Free and unlimited telehealth is also available through Academic Live Care. The Academic Live Care site also provides information about additional wellness services on campus that are available to students.